User Feedback on Physical Marker Interfaces for Protecting Visual Privacy from Mobile Robots

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***Abstract*—We present a study that examines the efficiency and usability of three different interfaces for specifying which objects should be kept private (i.e., not visible) in an office environment. Our study context is a robot "janitor" system that has the ability to blur out specified objects from its video feed. One interface is a traditional point-and-click GUI on a computer monitor, while the other two operate in the real, physical space: users either place markers on the objects to indicate privacy or use a wand tool to point at them. This late-breaking report presents qualitative feedback from users for improving the interfaces.**

I. Introduction

As mobile robots and remote presence systems become more common in our daily lives, we must address the privacy concerns of the people that share a physical space with these systems. In particular, *visual* privacy becomes a concern because people are worried about what is being viewed or recorded. Users may want to control what the remote operator sees, much as they would put away or hide valuables or pictures before a stranger visits. This paper presents a user study that explores three different methods users might use to specify what they want hidden. Because we are working with an actual physical space and real objects two of our methods are *physical*, i.e., they involve pointing at, or placing markers in, the physical environment.

II. Related Work

Research has revealed that humans often interact socially with machines. This phenomenon is often stated as *"Computers Are Social Actors" (CASA; [1])*. Any robot, then, can function as a social actor during a human-robot interaction. Broad discussions of privacy issues that are specific to robotics are only recently beginning to be published, especially outside of the robotics discipline. [2] gives a good overview as well as some newer insights. Two early studies in privacy-conscious robotics, [3] and [4], show that privacy preferences differ between individuals and are complicated, so privacy-conscious HRI research needs to study real people to be useful.

III. Approach and Implementation

Our focus in this paper is on the comparison of a traditional GUI interface to two different physical interfaces in the context of specifying that certain objects should be "private". Fundamentally, we are interested in how well each interface performs that task. Our three interfaces are (1) **The Marker Interface:** the user places a physical marker directly on objects; (2) **The Pointing Interface:** the user touches objects directly with a "wand" tool; and (3) **The Graphical Interface:** a traditional on-screen graphical interface where the user clicks on objects. Interfaces (1) and (2) are collectively referred to as the *physical* interfaces. In all three cases a monitor situated next to the objects showed the robot's view of the world with the objects marked as "private" blurred out.

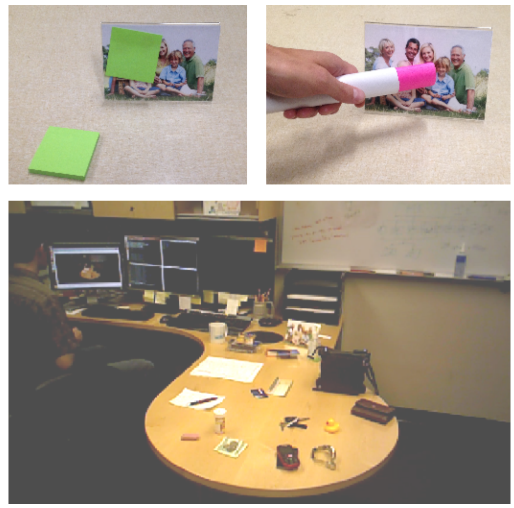

Fig. 1: The three interfaces used in the study. Top left: marker interface. Top right: pointing interface. Bottom: robot video feed displayed in the graphical interface.

All three interfaces, illustrated in Figure 1, were implemented on a Willow Garage PR2 robot using the Robot Operating System (ROS). For all three methods object selection consisted of specifying a 3d location ("tag") in the robot's camera frame. A 10cm axis-aligned cube was then centered around that point. All image data inside the projection of that cube was blurred.

IV. Methods

Each participant tried all three interfaces in turn, first practicing by tagging five objects and then tagging six additional objects designated by the experimenter. This was followed by a freeform task where the participant was asked to hide or tag objects using any combination of interfaces or by physically moving them to create a "private" office. The study was

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conducted in a single-occupancy office belonging to a faculty member in the College of Engineering. Only the participant, the experimenter, and a PR2 robot were present in the office during the study.

This late-breaking report presents qualitative feedback from users about the three interfaces. This feedback was gathered through written responses to survey questions at the end of the study as well as conversations between the experimenter and each participant about interface usability. Not presented here are results from quantitative measures: of interface usability, of user confidence that the systems worked, and of memory about which objects were tagged.

V. Results

Twenty-seven people (12 female and 15 male) participated in this study. Their ages ranged from 18 to 70, with a mean of 35.2 years.

A. General Observations

We have realized that the *time* required to tag objects with each interface will depend upon the context. For example, the two physical interfaces might require less time if the objects were all within arm's reach. Also, we made the graphical interface easier to use by placing all the objects within the robot's field of view; it might take much longer if the robot had to be teleoperated around the room or even multiple rooms to do the tagging.

Some participants noted that the marker interface was unique because the markers could be placed without the robot being present. Those same participants had the insight to worry that, if the robot needs to look at the target objects before they are blurred for the pointing and graphical interfaces to work, then the user's privacy could already be compromised if a remote person is watching through the robot's cameras.

B. Design Implications

Feedback – When using the two physical interfaces, people did not like having to look at the monitor to confirm each tag. Add feedback to the tagging tool by placing lights or speakers on the marker or wand, or by having the robot project something onto the scene.

Size and Occlusion – Marker detection should be done in the real, three-dimensional frame instead of image space. This will allow for checking whether a marker candidate is of the appropriate size, regardless of range. Also, 3d sensing and mapping could enable line-of-sight checks so that the system will not erroneously remove a tag that has simply been occluded by a person or other obstacle.

Detection Range – When markers are far away, they are too small to confirm as valid blobs. Since this means we cannot guarantee that no new tag has been placed beyond the effective marker detection range, perhaps the system should blur or redact all pixels beyond a specified range horizon. This would require a depth sensor. In that same vein, larger markers are better as long as they are not easily occluded.

Choice of Marker – Color markers are not robust to lighting conditions, occlusion, or other things of the same color. ARTags are another option, but must be quite large in order to be detected reliably, and are difficult to distinguish between for humans. We argue that a privacy specification interface would require a much more reliable marker-detector combination in order to be acceptable to users.

Gesture Timing – Participants found that touching each object for two seconds with the wand tool felt tedious. Future interfaces should reliably detect tagging gestures even if those gestures are very brief.

VI. Future Work

We received many reports about the negative impact on confidence caused by the limited range of the pointing interface. This suggests that future work should study the impact of technical malfunctions and limitations on user confidence about privacy protection. For example, one could design a study that manipulates the fidelity of the privacy tags—e.g., by flickering the blur effect—coupled with a Wizard of Oz technique if needed to guarantee the absence of uncontrolled malfunctions.

Feedback from the robot seems to be critical to whether users trust in the system. This feedback could express when tags are added or removed, as well as which filters are in effect. Examining different modes of feedback and the trust (even the *false* trust) they instill in users would be novel and important future work.

The apparent quality of each interface (i.e., whether it appeared shoddy or well-designed) may have impacted user confidence that it actually worked. A future study could manipulate the perceived quality of an interface by varying its appearance and the way it is described by the experimenter. This could reveal an important effect of apparent quality on user confidence.

People often choose between products without having tried them, sometimes using only television commercials or other advertisements to make a choice. Our study only tested our hypotheses on first-time interface users, but neglected two other populations: non-users who are given only a description of the interfaces and long-time interface users. Understanding how these populations differ and communicate could give nuanced insight into the social acceptance of privacy specification interfaces.

References

[1] C. Nass, J. Steuer, and E. R. Tauber, "Computers Are Social Actors," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ser. CHI '94. New York, NY, USA: ACM, 1994, pp. 72–78.

[2] R. Calo, "Robots and privacy," in *Robot Ethics: The Ethical and Social Implications of Robotics*, P. Lin, G. Bekey, and K. Abney, Eds. Cambridge: MIT Press, 2010.

[3] D. Butler, J. Huang, F. Roesner, and M. Cakmak, "The Privacy-Utility Tradeoff for Remotely Teleoperated Robots," in *Proceedings of the 10th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, Portland, OR, 2015.

[4] A. Hubers, E. Andrulis, T. Stirrat, D. Tran, R. Zhang, R. Sowell, C. M. Grimm, and W. D. Smart, "Video Manipulation Techniques for the Protection of Privacy in Remote Presence Systems," in *HRI 2015 Extended Abstracts*, Portland, OR, Mar. 2015.